# Vision & Vision-Testing

illustrated

…dix

…elating to Vision.
…ates for

…nment Service.
…Army and
The Royal Navy.

Buxton

A. Ch. Argue.
Stittsville P.O.
Ont

# VISION

AND

# VISION-TESTING.

LONDON : PRINTED BY

T. G. BURNS AND CO., 170a, GREAT PORTLAND STREET, W

# VISION

AND

# VISION-TESTING.

WITH PRACTICAL TESTS.



ILLUSTRATED.



BY

A. ST. CLAIR BUXTON, F.R.C.S.,

ASSISTANT-SURGEON TO THE
WESTERN OPHTHALMIC HOSPITAL,
LONDON.



LONDON:
PUBLISHED BY PICKARD AND CURRY,
195, GREAT PORTLAND STREET, W.

1887.

TO

# SIR JOSEPH FAYRER,

## K.C.S.I., L.L.D., M.D., F.R.S.,

FELLOW OF THE ROYAL COLLEGE OF PHYSICIANS OF LONDON.

FELLOW OF THE ROYAL COLLEGE OF SURGEONS OF ENGLAND.

HONORARY PHYSICIAN TO THE QUEEN

AND TO

THE PRINCE OF WALES;

PHYSICIAN TO THE DUKE OF EDINBURGH.

PRESIDENT OF THE MEDICAL BOARD, INDIA OFFICE.

CORRESPONDING MEMBER OF THE ACADEMIE DE MEDICINE DE FRANCE,

&c. &c.

This little Book

IS DEDICATED

IN GRATEFUL REMEMBRANCE OF HIS

UNVARYING KINDNESS.

# PREFACE.

I HAVE attempted in the following pages to give a general idea of the Anatomy and Optics of the Eye, in language readily understood by a non-professional reader.

The introduction of a few technical terms has been unavoidable; yet it is hoped that the description will prove not only lucid, but interesting, to those desirous of becoming acquainted with the subject.

Minute Histology and Physiology have purposely been avoided, the statement of the broader facts alone having been deemed sufficient for the object in view.

School primers and other very elementary works give but a faint conception of the beauties of the eye; whilst the deeper and more scientific text books are far too comprehensive for the general reader.

I have striven to steer a midway course—to teach, but not to weary.

The aim of this little volume will have been amply achieved should it succeed in affording a fair insight into the phenomena of Vision, and the physical conditions on which those phenomena depend.

A. St. Clair Buxton.

*January*, 1887.

18, Orchard Street, Portman Square, W.

# CONTENTS.

## PART I.



## PART II.



## PART III.



## PART IV.



## PART V.



## *APPENDIX.*

# VISION AND VISION-TESTING.

## PART I.

### THE EYE CONSIDERED AS A CAMERA.

OUR organs of sight—the eyes—afford, perhaps, the most interesting and attractive subject for thought and study to be found in the human body.

Apart from their extreme value to us as means of making ourselves familiar with our surroundings and so enabling us to perform the duties, and reap the enjoyments, of life they offer special advantages for observation over other organs, quite as wonderful in themselves, by the fact of their being exposed to view, and thus coming under more direct and practical scrutiny.

We can examine not only the outside, but also,

by means of a simple instrument, the interior of the eye.

But before proceeding to the investigation of minute details in construction of anything, it is well to get a general idea of what that thing is, and of what it does.

Let us, therefore, now take a good broad view of this marvellous piece of apparatus; and while doing so, let us remember that we are not inspecting a photograph or fine engraving of it, but merely looking at a very rough sketch—in fact a mere diagram in words.

What, then, is the eye; and how does it fulfil its duties?

Further on will be found comparisons between the eye and a photographic camera. The eye, in fact, *is* a sort of camera, and it works in every way like one.

Light forms pictures within it, and these pictures are rendered sensible to us by exciting the retina and producing impressions which are transmitted to the brain. Thus the retina may, in one way, be considered to correspond to the sensitized plate of the camera.

The pictures of the photographic camera are

reproduced on paper, while the pictures cast upon the retina may be reproduced in our minds, as memory.

We all know the sensation induced by thinking of things we have seen. We seem to see them again; we are calling up the pictures of memory and are gazing at the work of the human camera on the brain.

And what is a camera?

In its simplest form it is a wooden box lined with black velvet, with a magnifying glass in front, fitted into a brass tube, which can slide in and out. On the outer end of this brass tube fits a lid (like a little cap) which pulls off easily.

At the back of the box—and therefore opposite the magnifying glass—is a piece of ground glass, which can be removed, when the photographer chooses, to give place to the sensitive plate.

Place a black cloth over your head and over the camera (taking care not to cover the magnifying glass) so as to exclude all light. You will see a picture of everything in front of you portrayed on the ground glass. It may be a little indistinct, but you can readily make it clear by shifting the magnifying glass a trifle in or out, as the case may be, until you find it well focussed.

The picture is upside down, but still you can recognize each object perfectly.

If a permanent copy of this picture be required, the ground glass is removed and a plate, rendered, sensitive by being covered with nitrate of silver, is put into the groove which was occupied by the ground glass. The light focussed by the magnifying glass acts on the sensitive film by what is known as *actinism*, darkening it in proportion to the intensity of the light on different parts of the original object focussed.

If the superfluous nitrate of silver be now washed off, the picture can be permanently "fixed." This is called the negative and from it any number of copies can be printed.


FIG. 1.

A, The lens, or magnifier.
BB, The iris, or diaphragm.
ccc, The retina, on which the picture is produced.

A, The lens, or magnifying glass
BB, The diaphragm.
cc, The ground glass on which the picture is produced.

How, it will now be asked, does this familiar contrivance resemble that beautifully delicate structure, the eye?

Simply in this way.

The eyeball is nothing more nor less than the counterpart of the box lined with black velvet.

There is a magnifier—not of glass, certainly, but nevertheless a lens of equally clear and transparent material—which plays the same part as the glass in the brass tube. The function of the ground glass of the camera is discharged in the eye by the retina.

The photographer uses a sensitive plate in the camera, as mentioned above, which is darkened by the action of light. In the case of the eye, the retina not only plays the part of the ground glass, but also that of the sensitive plate, and the action of light upon it is communicated to the brain by means of the optic nerve which joins it (telegraphically) with the retina.

In the photographic camera the box contains nothing but air; but in the human camera, there is clear fluid to prevent the collapse of the eyeball itself—for it is not rigid like the wooden box, but quite soft and yielding, and would get out of shape

if it were not completely full of something more dense than air to give it support.

The photographer adjusts the focus by pushing the magnifying glass further in or out; but the lens of the eye is adjusted to a correct focus by an alteration in its magnifying power, which, as will be demonstrated hereafter, comes to exactly the same thing. For this reason it is not necessary that there should be any projecting tube—like the brass tube of the camera—and, therefore, the magnifying glass of the eye occupies a fixed position just inside the front of the eyeball.

The photographer is compelled to shift the position of his camera, stand and all, each time he desires a change of view. But the human camera can be moved at will within its socket without altering the position of the head. This movement is accomplished by means of muscles attached to the external surface of the eyeball.

The brass tube of the camera is provided with a disc of thin metal with a round hole in its centre. This diaphragm, as it is called, slips into the tube just in front of the magnifying glass, and so shuts out all rays of light except those which pass through the hole. The photographer has a number of dia-

phragms, the size of the hole varying in each. He employs one with a large hole when the light is feeble, and one with a small hole when the light is very strong. By these means he ensures the ingress of exactly the right amount of light to produce the most vivid picture.

The eye, too, has its diaphragm. It is called the iris, and is placed just in front of the lens.

A glance at the diagrams of the camera and of the eye will suffice to render the comparison intelligible (Fig. 1).

Lastly the photographic camera has a brass cap which fits over the magnifying glass to cover it up when not in actual use. This not only shuts off the light when the sensitive plate has been exposed a sufficient time, but also serves to prevent the entrance of dust, and protects it from injury. The eye has its eyelids, which do much the same thing.

So it will be seen that there is really a great similarity between these two optical instruments. The principles in both are identical.

The general resemblance of the various parts of the eyeball to those of an ordinary camera having now been indicated the reader will naturally inquire

how the organs of vision are brought under control of the will.

In order to comprehend the different phenomena of vision, it is necessary that we should first make ourselves acquainted with the anatomy and optics of the eye.

# PART II.

## ANATOMY AND OPTICS OF THE EYE.

THE eye has been likened in the preceding pages to a camera, and the general points of resemblance have been shown. We must now look into the subject a little more minutely.

The globe, as the eyeball is generally called on account of its spherical form, is placed in a hollow socket called the orbit—because it holds the orb—formed by the bones of the face.

The orbit is lined with soft, yielding material (principally fat) which allows the globe to glide and rotate easily in its bed without much friction.

The motions of the eye are, as we all know, rather limited in extent, but they suffice to render it easy for a person to look at many different objects

without the inconvenience of changing the position of the head; thus saving a great deal of fatigue, for the whole head being so much more ponderous than the eye, greater exertion is needed to move it.

The movements of the eyeball are effected in the same way as all other voluntary movements in the body—by muscles. These are six in number for each eye. One turns the eye upwards; another downwards. A third turns it inwards; a fourth outwards. The other two muscles are reserved for the purpose of producing a slight rotation of the eyeball, like that of the handle of a door, in either direction.

But in addition to the facility they afford for altering the line of vision, these muscles also play another very important part. Being fixed by one end to the eyeball and by the other end to the bony orbit, they hold the globe in its place and prevent it from becoming dislodged from its socket. And considering that if this accident were to happen the communication between the eye and the brain (the optic nerve) would be severed, with incurable blindness as the result, it is obvious that they are a source of safety, as well as of convenience, by mooring the eye in its cavity.

While touching on this point it may not be out

of place to state here that the startling narratives which are sometimes so glowingly related concerning the atrocities of oculists, who pull out eyes and lay them on the cheeks of their owners for unexplained purposes—but which, it may be gathered from dark hints, appear to be dimly connected with soap suds and a scrubbing brush—are entirely without foundation, and exist only in the fertile imagination of the narrators.

Once removed from its orbit, the eye is irreparably damaged.

The globe, which corresponds in function to the photographer's mahogany box, is a hollow ball containing the lens; a diaphragm, called the iris; and the fluids of the eye, known familiarly as the humours.

For the sake of convenience we will now call the ball itself the *envelope*—reserving the words globe and eyeball to signify not only the envelope, but also its contents. It will, therefore, become evident that strictly speaking it is the *envelope* only which corresponds to the box of the camera.

The humours of the eye keep the envelope sufficiently distended—by completely occupying all the space not taken up by the lens and iris—to

prevent it from being squeezed out of shape, which would otherwise constantly happen, the material of which the envelope is composed being very flexible, though fairly strong.

The envelope is so opaque that no light can pass to the inside except through its front where it is a trifle more prominent—like a little watch-glass fixed on to the globe. This prominent portion of it is quite transparent, and is known as the *cornea.* It is, in fact a window through which light easily penetrates before reaching the lens.

In the photographic camera there is, it is true, no such window. But then the lens of the camera is of glass, and less likely to become injured than the lens of the eye, which is of infinitely more delicate material. Again, the envelope of the eye would collapse, in consequence of the escape of its contents, if it were not completely closed in front as well as elsewhere; whilst the box of the camera is rigid, and keeps its own shape.

So much for the cornea. The rest of the envelope is made up of three layers or coats.

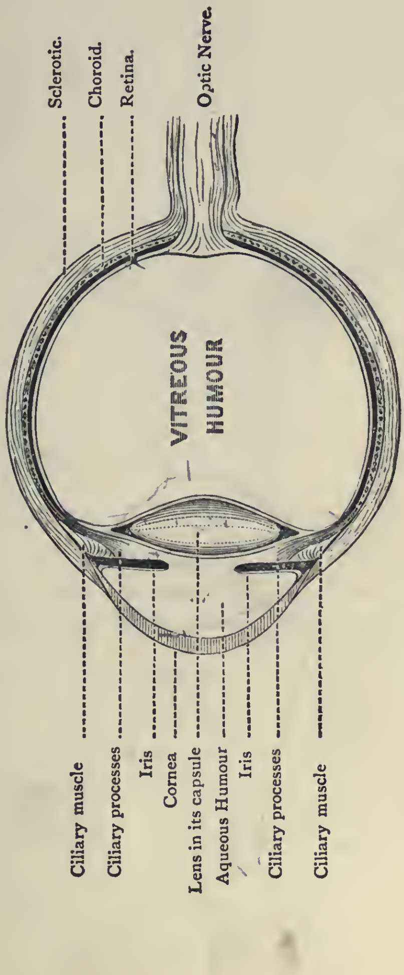



FIG. 2.—VERTICAL SECTION THROUGH THE EYE

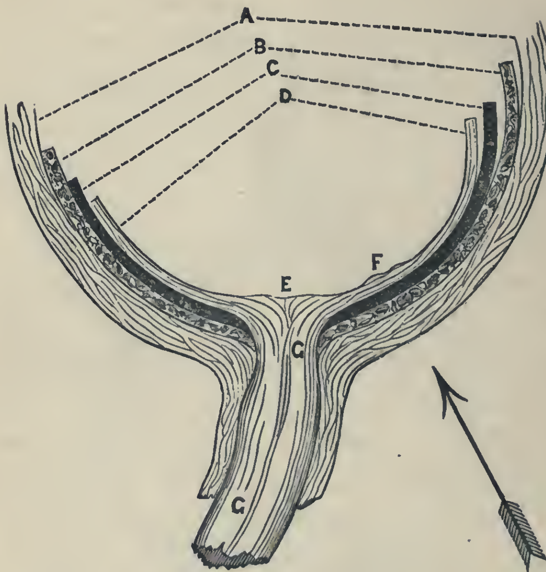



FIG. 3,—HORIZONTAL SECTION SHOWING THE DISPOSITION OF THE COATS OF THE EYE, THE BLIND-SPOT AND THE YELLOW-SPOT.

A, Sclerotic; B, Choroid; C, Retina (pigmentary layer); D, Retina (nerve layer); E, Blind spot; F, Yellow-spot; GG, Optic nerve. The arrow shows the direction of the axis of the Eye.

The outer layer—of which a portion is visible round the cornea, and commonly called the "white of the eye"—is the sclerotic. It is comparatively thick, fibrous, and strong. Being smooth, it glides and rotates easily on the bed or cushion, before alluded to, which lines the orbit.

It is to the sclerotic that the six muscles which pull the eye into its various positions are attached.

The next (the middle) layer is the choroid.

It is thin, but contains a large supply of blood, in a network of fine blood-vessels, for the nourishment of the adjacent parts.

At the free edge of this coat—that is where it approaches the cornea—there exists a sort of fringe, the fine fibres of which are named the ciliary processes. This fringe is intimately connected with a small ring of muscular tissue, the ciliary muscle, which plays an important part in adjusting the eye to a proper focus.

The innermost coat is the retina, which is a delicate membrane ending just short of the choroid. It is itself composed of two layers—one of nerve-matter lining the other; the latter being of a dark colour, and called the pigmentary layer.

The nerve-matter is really a continuation of the optic nerve, which spreads out as a film over the coloured or pigmentary layer, and thins out gradually so as to become lost at the ciliary processes.

This nerve-layer of the retina is peculiarly sensitive to light, and its duty is to receive impressions of various luminous rays which fall upon it and to

communicate them to the brain, where they excite a sensation which we call *vision.*

The pigmentary layer of the retina, which also ends at the ciliary processes, is so dense that it adds to the opacity of the envelope. It also serves to absorb extraneous rays of light which find their way into the eye through the cornea, but which fall too obliquely on the lens to be correctly focussed.

Were it not for the absorbing power possessed by this colouring matter—like that of the black velvet which lines the photographic camera—any extraneous, and therefore unfocussed, rays would interfere with the vividness of the picture on the retina.

This fact is readily grasped if we remember how faint the pictures thrown by a magic lantern become, if the room be not kept in total darkness.

The optic nerve (Fig. 3) is a thick bundle of nerve-matter proceeding from the brain through an opening at the back of the orbit.

It pierces the sclerotic and choroid coats, and also the pigmentary layer, and having thus reached the inner surface of the envelope of the eye, it spreads out, as has been stated, to form the sensitive portion of the retina.

The function of this nerve is to transmit (telegraphically) to the brain the impressions made by light on the retina. The actual spot at which the optic nerve enters the envelope to spread out and form the sensitive layer of the retina is, curiously enough, the only spot on the retina absolutely insensitive to the effect of light. For this reason it is called the "blind-spot." This point is not in the principal axis of the lens, but lies about one-tenth of an inch to its inner side, as seen in the diagram (Fig. 4). The point which accurately corresponds to the axis of the lens (and therefore of the whole eyeball) is, on the contrary, the most highly sensitive spot in the retina, and is known, from its colour, as the "yellow-spot."

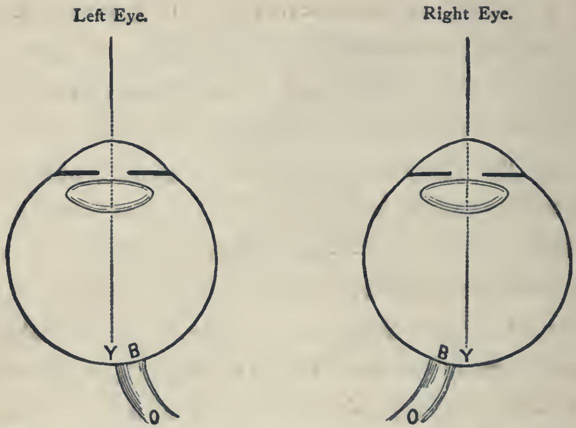



FIG. 4.—HORIZONTAL SECTION THROUGH BOTH EYES, VIEWED FROM ABOVE.

B, Blind-spot corresponding to entrance of O, optic nerve, on inner side of axis. Y, Yellow-spot in the axis of the Lens, the most sensitive part of the Retina.

N.B.—The dotted lines represent the axis in each eye.

Rays which fall on the yellow-spot are most keenly appreciated, whilst those which fall on the blind-spot are not seen at all. This latter fact can be readily demonstrated by the following experiment.

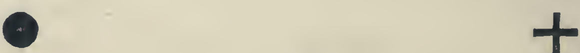


FIG. 5.

Close the left eye, and direct the right eye towards the circular spot (Fig. 5). If the page be held

at arm's length, both the spot and the cross will be visible. Still gazing intently at the circular spot, and keeping the left eye closed, bring the page very gradually nearer to the face. The cross will now disappear from view, only to re-appear when the page is brought still nearer. At the moment of disappearance the rays from the cross are falling exactly on the blind-spot.

In addition to the large quantity of nerve-matter supplied by the optic nerve, the coats of the eyeball are well furnished with numerous other nerves of smaller size which are distributed between them, and which pierce them at various points. Some of them carry impulses (messages) of *motion* from the brain to the muscular fibres of the iris and ciliary region; while others carry impulses of *sensation* from the eye to the brain.

Again, the muscles which pull the eyeball into its various positions receive their telegraphic messages through special sets of nerves which also come from the brain. These do not enter the coats of the eye, but lie between the globe and the bony orbit or socket.

The cornea, as has been said before, is the window of the eyeball. Through its transparent

substance rays of light are admitted. These pass through the pupil and fall on the lens, which brings them to a focus on the retina.

Here they produce pictures similar in all respects to those on the ground-glass slide of a photographic camera.

The lens—sometimes called the crystalline lens—is a perfectly transparent body, much resembling an ordinary magnifying glass in shape and function. It is fitted accurately into a closed sac of extremely delicate structure. This sac, called the capsule of the lens, invests it so closely, and adheres to it so firmly, that it may almost be considered as a part of the lens itself—an outer part, tougher and more fibrous than the inner portion.

The material of which the lens is composed is of an elastic or springy nature; and the *tendency* of the lens is to assume a more or less globular form (B, Fig. 6). But this tendency is checked and the flattened shape preserved by means of the capsule which is tightly fixed all round its edge to the envelope of the eye. Thus the capsule is well stretched out all round (A, Fig. 6).

It will be remembered that the lens is situated just inside the eyeball, its edge corresponding pretty

nearly with the line of boundary between the sclerotic and the cornea, in the region of the ciliary processes. In other words, it is placed just a little way back from the window. Thus it divides the interior of the eyeball into two separate cavities—one in front of it, the other behind it.

Immediately in front of the lens* is a thin partition or screen, perforated in its centre by a round hole, to admit the rays of light. This screen, or diaphragm, is the iris (Fig. 2); and the hole in it is called the pupil.

The iris is seen through the cornea and is often called "the coloured part of the eye."

It is opaque, and contains pigment the hue of which varies in different individuals.

The pupil appears to be black, owing to the darkness inside the globe.

The use of the iris is to prevent too much light being thrown on the lens, and in this respect it resembles the metal diaphragm of the camera.

In a bright light the pupil becomes small (con-

* The hindermost surface of the iris is in actual contact with the front layer of the capsule of the lens. But in the diagram it is shown as being placed a little way in front of the lens capsule. This is merely for the sake of clearness.

tracts) so that few rays may enter ; whereas in a dim light it enlarges (dilates) to enable more to pass in.

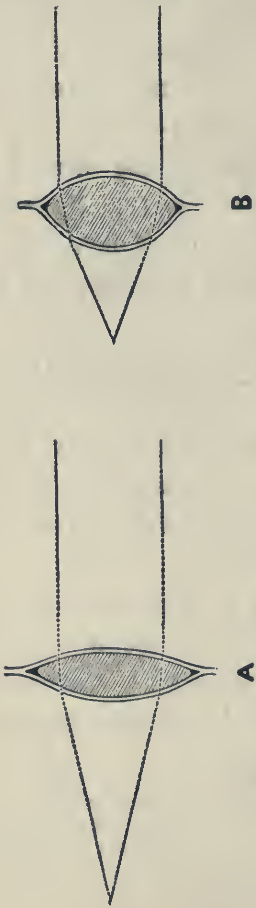



Fig 6.—Diagram representing Crystalline Lens in its Capsule.

A, when the capsule is stretched tightly.
B, when the capsule is relaxed.

N.B.—The dotted lines show the directions taken by rays of light coming to a focus, A, when the lens is flattened ; B, when more globular.

The size of the pupil is controlled by two sets of muscular fibres in the substance of the iris. One set is arranged in a ring round the pupil. When this ring of fibres contracts, the pupil is diminished in size.

The other fibres are disposed radially from the circumference of the iris towards the pupil, so that they are situated at right angles to the first set. When these radiating fibres are brought into action, the pupil is dragged more widely open (dilated).

Each set of fibres is governed by a separate and opposing nervous apparatus.

In bright light the circular fibres are more strongly stimulated than the others (their antagonists) and overcome them, so that the size of the pupil is diminished (Fig 7). In dim light the circular fibres are not sufficiently stimulated to resist the radiating set, and these get the upper hand—so that the pupil enlarges (Fig. 8).

The two sets being nicely balanced, the utmost sensitiveness is insured.

Fig. 7.

Circular fibres of Iris strongly stimulated by bright light. Pupil contracted.

Fig. 8.

Radiating fibres of Iris overcoming the action of the circular fibres in dim light. Pupil dilated.

Diagram illustrating Contraction and Dilatation of the Pupil.

The photographer imitates this contraction and dilatation of the pupil by using in his camera various diaphragms or screens having apertures of different sizes, according to the brilliancy of the light in his studio.

In order that the globular shape of the eye may be maintained, and in order also to assist the lens in bringing the rays of light to a vivid focus on the retina, the spaces in front and behind the lens are filled up, as before stated, with the so-called humours.

These are, the aqueous humour—which fills up the *front* space; and the vitreous humour—which occupies the space *behind* the lens (Fig. 2).

The space taken up by the vitreous humour is, of course, much greater than that taken up by the aqueous, because the lens is so near the front of the eye. The consistency of this humour is also much denser.

The aqueous humour, as its name indicates, is a thin, clear, watery fluid, in which the iris can readily move when the pupil contracts or dilates.

The vitreous humour, on the other hand, is thick and viscid—though quite as transparent, and much resembles clear jelly.

It has been shown that the lens has a tendency to assume a form approaching the spherical, by reason of its elasticity.

It has also been shown that this tendency is held in check by the fact of its capsule, or sac, being stretched out tightly, all round, at its edge.

It is obvious, therefore, that the focal strength of the lens varies according to the amount of *tension* (stretching) to which its capsule is subjected (Fig. 6).

This variation in tension is brought about by the contractions and relaxations of the fibres of the ciliary muscle, before mentioned.

These contractions and relaxations are completely

under control of the will, and they take place simultaneously in both eyes.

Moreover, the same effort of will which controls the two ciliary muscles, has an effect also on the outside muscles, so that the two eyes are always looking at one and the same object, which object is accurately focussed on corresponding portions of the two retinæ.

The eyelids are two movable folds or covers—the upper lid and the lower lid—placed in front of each eye (Fig. 9).

They are for the purpose of protecting the eye from injury; and also, when closed, to give rest to the retina by excluding all light.

They are composed of skin on the outside; while on their inner surfaces they are lined by a thin membrane, called the conjunctiva, which is prolonged (*reflected*) on to the surface of the eyeball and which here is adherent to the sclerotic over that portion of it which is seen all round the cornea (Fig. 9).

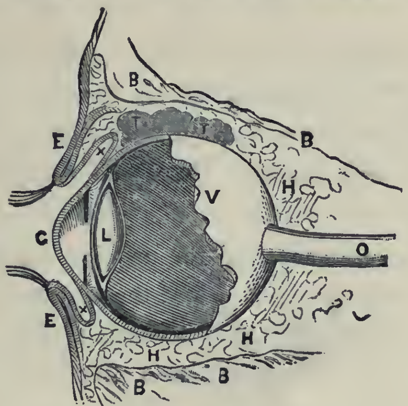



FIG. 9.—DIAGRAMATIC SECTION THROUGH RIGHT ORBIT (VERTICALLY). MUSCLES OMITTED.

**BBBB, Bony Orbit; V, Envelope of the Eye; O, Optic Nerve; L, Crystalline Lens; C, Cornea; EE, Eyelids; XX, Conjunctiva; HHH, Fat, lining Orbit; TT, Lachrymal Gland.**

The fact that the conjunctiva is prolonged on to the eyeball, and adheres to it, is an important one, inasmuch as it affords a safeguard against injury by dust or other foreign bodies, which might work their way behind the eyeball and cause intense irritation and mischief.

As it is, nothing can pass behind the eye without perforating the conjunctiva, which is sufficiently strong to resist all ordinary floating particles.

The conjunctiva does not extend over the cornea itself, but becomes gradually thinned out, and lost, on the edge of this structure.

The conjunctiva contains numerous tortuous, delicate, blood vessels, which become distended with blood and produce the "blood-shot" appearance so well known, when the conjunctiva is irritated.

In the substance of the eyelids are plates of gristle (cartilage) which afford them a certain degree of firmness and rigidity. There are also minute glands, fibrous material, and channels for the tears.

The upper lids are each furnished with muscles, which, by contracting, raise the folds and so "open the eyes." When these muscles are relaxed, the lids droop.

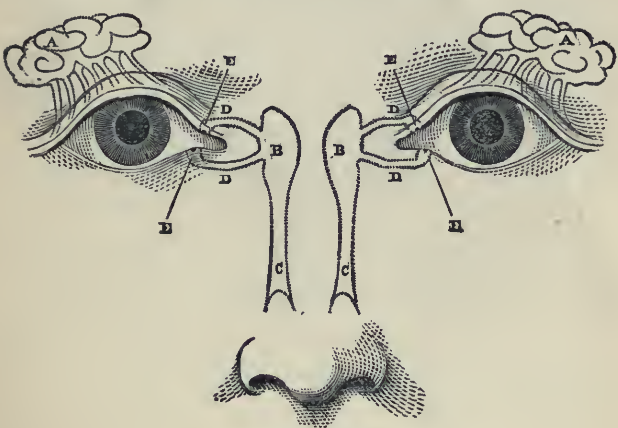
There is also a large ring of muscle which surrounds both the upper and lower lid—called the orbicular muscle. It overlies the more or less circular edge of the socket, and, when contracted, firmly closes the lids together.

The tears are formed by a gland (the lachrymal gland) which occupies a position in the orbit alongside the eyeball close to the temple (Figs. 9 and 10).

The tears are conducted from the lachrymal gland to the surface of the conjunctiva by small

canals (ducts) (Fig. 10). The unconscious winking of the lids keeps the surface of the eye well-moistened by distributing the tears over it. This assists in lessening friction.

The tears escape from the eye by a minute opening (punctum) on the edge of each lid, near the nose. Each punctum is really the mouth of a small tube (canaliculus) through which the tears are led into an egg-shaped chamber (the lachrymal sac) near the bridge of the nose. From the lachrymal sac they pass down a bony tube (the nasal duct) which opens into the cavity of the nose (Fig. 10).




FIG, 10.

A,A, Lachrymal Gland; B,B, Lachrymal Sacs; C,C, Nasal Ducts; D,D,D,D, Canaliculi; E,E,E,E, Puncta.

Everybody is conscious, in the act of weeping, of a copious flow of fluid from the nostrils. This flow is due to the rapid escape of tears down the nasal ducts.

If more tears be excreted than can escape by these legitimate channels, an overflow down the cheeks is the result so familiar to us under great emotion.

The eyelashes assist the lids in keeping floating particles of dust and grit out of the eyes.

# PART III.

## VISION.

TAKE a lighted candle, *a* (Fig. 11) into a dark room, and place it on a table a few feet from the wall.

Now hold a common magnifying-glass, *c*, between the candle and a sheet of white paper, *b*, pinned flat against the wall.

If you happen to have placed the magnifying-glass at precisely the right distance from the paper—a distance which varies according to the strength of the glass—you will see an exact picture of the lighted candle, but upside down, on the sheet of paper (Case I.).

Now gradually bring the glass nearer to the paper. You will find that the picture of the candle—just now so vivid—will become blurred and indistinct (Case II.).

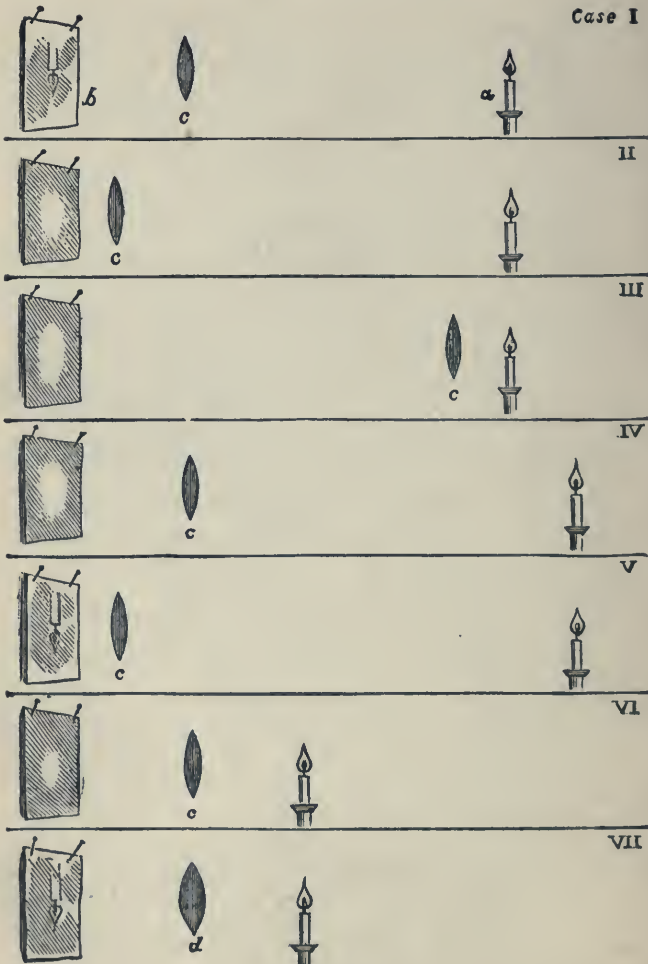



FIG. 11.

The same result will follow if, instead of advancing the glass towards the paper, you move it nearer to the candle (Case III.).

In other words, *It is impossible to throw a well focussed image of the candle on to the paper unless the magnifying glass be at exactly the right distance from that paper.*

Once more hold the glass so as to show the picture accurately, and while keeping the glass perfectly still, ask another person to move the candle further off. Again you will find the image grow indistinct (Case IV.).

The same thing will happen if, instead of moving the candle *further* from the glass, your assistant move it *nearer* to it (Case VI.).

You will also find that in order to obtain a clear picture of the candle on the sheet of paper, *the further the candle is moved away, the nearer you must hold the magnifying-glass to the paper—and vice versa* (Case V.).

In the place of the lighted candle in a room, if you throw an image of the sun on to a sheet of paper, and accurately focus it so that a small well defined spot of vivid light is produced, the distance between the magnifying-glass and the bright spot is

called the *focal length*, indicating the *strength*, of the glass used.

Taking two or more magnifying-glasses of equal diameter, the glass which is thickest in the middle will have the shortest focus—or, in other words, will be the *strongest* glass.

To revert to the experiment with the lighted candle, the image became blurred when the candle was moved away, but became clear again when the glass was brought nearer to the paper (Case V.).

It would, however, have been as easy to maintain the same vivid accuracy of picture *without moving the glass lens nearer to the paper*, if a rather *weaker* lens had been substituted for the previous one.

Similarly, when the candle was brought *nearer* to the magnifying-glass, and the image became blurred in consequence (Case VI.), a stronger lens, *d*, (in place of the one used, *c*) would have restored the clearness of that image (Case VII.)—which otherwise could only have been accomplished by increasing the distance between the lens and the paper.

Note these two facts carefully as a clear appreciation of them is necessary in order to understand the action of the optical apparatus of the eye.

From these experiments, which the reader is

advised to perform for himself, it becomes evident that an accurately focussed image of the lighted candle can be produced on the sheet of paper *by selecting a lens of exactly the right focal strength*, without altering the distance between it and the paper, no matter how far off or how near (within certain limits) the lighted candle may be placed.

Now this is precisely what happens in the case of the eye.

We have already seen that by a mere effort of will we can readily weaken or strengthen the magnifying power of the crystalline lens, by stretching or relaxing the capsule. The distance between the lens and the retina does not alter. Nevertheless, the lens is constantly at work focussing objects at varying distances on the retina. It is enabled to do this quite accurately because it accommodates itself exactly, *by altering its magnifying power*, to suit the requirements of each and every case.

There are of course, certain limits to the variations in strength in the lens, and for this reason, certain limits in focussing.

The human eye is so arranged—that is, the strength of the lens and its distance from the retina

is such—that when the lens is at its flattest the most distant objects in nature are accurately focussed; while, when the lens assumes its most globular form, objects only a few inches from the face can be perfectly seen.

The impediments to *extremely* distant vision are therefore not the want of flatness in the lens; but result principally from the following conditions:—

(*a*).—The smallness of the size of the object looked at.

(*b*).—The imperfect transparency of the atmosphere.

As regards size, the object looked at must be at least of sufficient dimensions to subtend an angle of five minutes in order to be clearly distinguished (Fig. 12). In other words, if the rays travelling from the object's extreme limits of breadth unite at the eye so sharply as to form an angle of less than five minutes, the object may be perhaps *discerned*, but its details of form will not be clear, the pencils of light falling on the retina too acutely to produce the necessary effect on the nerve-matter (Fig. 13).

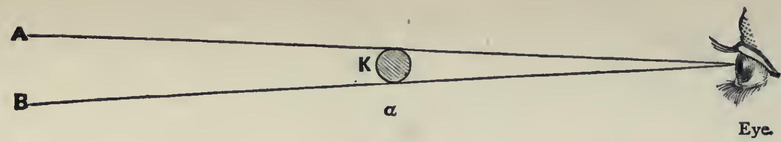



FIG. 12.

Fig. 12.—The lines A and B which converge at the Eye are supposed to enclose an angle of five minutes. The object K situated at *a* exactly subtends the angle of five minutes, and is therefore clearly visible.

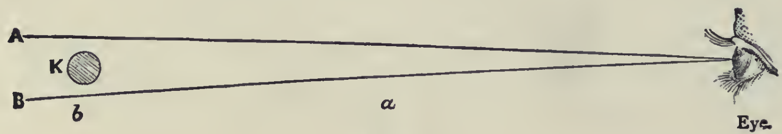



FIG. 13.

Fig. 13.—The same object K at *b* is too far removed from the Eye to subtend the angle of five minutes, and therefore, although it may be perhaps discerned, is not clearly seen, and its *form* cannot be recognized.

For example, a star is seen as a brilliant point, without definite shape. It is extremely far away from us, and its size is not sufficiently great to subtend, at that distance, an angle of five minutes.

On the other hand, the moon is seen to be round, because its diameter is large enough, relatively to its distance from us, to subtend the angle of five minutes, and the retina is therefore able to appreciate its form.

With regard to haziness from atmospheric causes—the other principal impediment to distant vision—we are all so perfectly conscious of this obvious bar that it is needless to dwell on it.

As to the limit of focussing in the opposite direction—when the object looked at is very near the eye—the lens is able only to increase its focal strength enough to render clear vision possible at some inches (Fig. 14).

The ordinary well-formed eye is able to see very small print quite comfortably at from 12 to 15 inches. When the distance between the eye and the print is much reduced the image becomes indistinct because the rays of light have not yet reached a focus when they strike the retina (*Vide* dotted lines in Fig. 15).

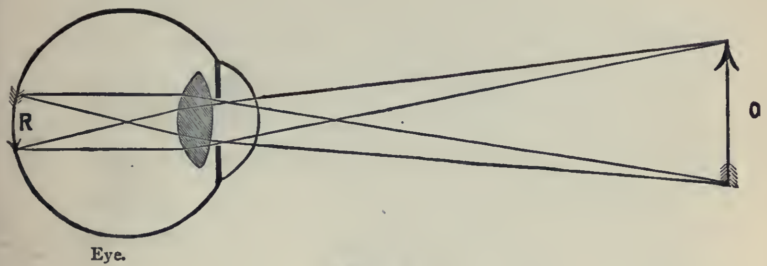



FIG. 14.

The object O sufficiently far from the Eye to produce a clear image on the retina at R.

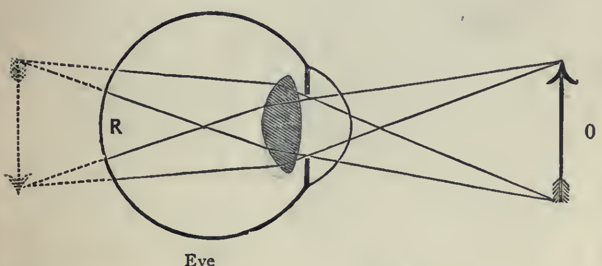



FIG. 15.

The same object O too near the Eye to be focussed on the retina R, therefore a blurred image is produced (*Vide* Fig. 11, Case VI.).

NOTE.—It has been assumed, for the sake of simplicity, that the entire object, O, can be seen at once; and the rays of light coming from its extremities have been depicted as falling exactly on the retina. These lines, comprising the whole object, it will be noticed, are drawn converging towards each other at the eye; and it has been taken for granted that these converging rays *can* be focussed on the retina of a well-formed eye. As a matter of fact, if an object be very large, only a portion of it can be accurately seen at any one moment, and the portion thus accurately focussed is comprised between *parallel* (or nearly parallel) rays. We are in the habit of focussing various portions of a large object in quick succession when we desire to obtain a very exact idea of the whole. But we are also often content to see the *whole* of a large object (though less accurately than if we looked at it bit by bit)—especially when that object is at a considerable distance from us; and to do this we sacrifice the acuteness of the focus for the sake of taking in the parts contained between *converging* rays. In other words, instead of *minutely* inspecting portion after portion of any given object, and *exactly* focussing each of these portions, one after

the other, we frequently prefer to get a rather less vivid image for the sake of seeing the whole object at a single glance. Only a moderately large object can even then be included in the field of vision, a fact that will at once be apparent if we remember that the outer parts of the view before us are less distinct than the central points. In the following diagram the unbroken lines, emanating from a *portion* of the object, are parallel to each other, and are therefore accurately focussed. The dotted lines, coming from the extremities (and therefore comprising the whole) of the object, are *converging*. The latter, it will be seen, come to a focus just before they reach the retina, and the *whole* object, between the letters *a*, *b*, is therefore not so clearly seen as that portion of it which lies between the letters *c*, *d* (Fig. 16).

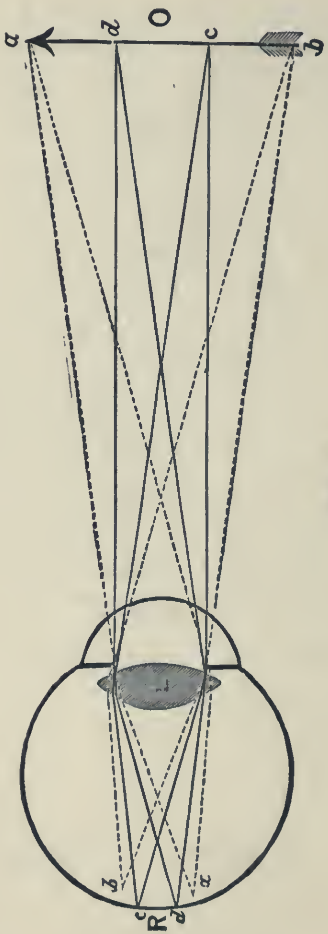



FIG. 16.

# PART IV.

## ERRORS OF REFRACTION.

WE have hitherto spoken of the eye as if it were a perfect piece of optical apparatus. We have assumed that the retina was at precisely the proper distance from the lens to receive correct impressions; that the lens itself was as accurate in form as a magnifying-glass which has been ground into shape by an optician; that the cornea was also a perfectly even transmitter of light, having a surface curved equally in each direction like a watch-glass; and lastly that the whole globe was as round and true as the optical requirements of the eye for distinct vision demanded.

These assumptions are scarcely ever strictly true—but the variations and divergencies from a mathe-

matically correct form of eye are happily so slight in a large majority of persons that the eyes of this majority may be considered practically perfect.

We will now pass to the less fortunate minority, and consider in what respects their eyes may be defective; the means of detecting these errors of form; and how these errors are corrected by appropriate glasses.

It will be remembered that in order that the brain may receive a *distinct* idea of the picture on the retina, that picture must be accurately focussed in all its details. This can only occur when the rays converge on the retina in sharp, clear, pencils of light whose points represent the corresponding points of the object from which they have proceeded.

Should it happen, then, that the eyeball is not round, but more like an egg—or, in other words, elongated from front to back—the rays of light which pass through the crystalline lens will be brought to a focus before they reach the retina (Fig. 17) and the same blurred effect will be produced there as in the candle experiment when the magnifying-glass was held too far off from the paper (Fig. 11; Case III.).

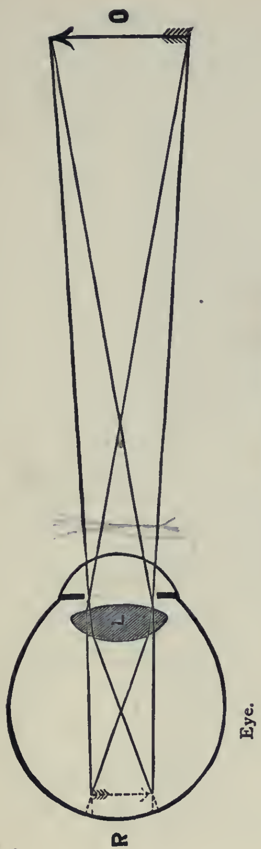



FIG. 17.—MYOPIA ILLUSTRATED.

The distance from the Crystalline Lens, L, to the retina, R, being too great, the object, O, is focussed before reaching the retina, and therefore an indistinct image is produced.

This condition of eye is common, and produces the effect known as myopia or short-sight.

The remedy in the experiment just mentioned

was either *to move the glass nearer to the paper ; to move the candle nearer to the glass ; or to employ a weaker magnifying-glass in the place of the one used.*

Any of these methods reproduced a vivid picture of the candle on the sheet of paper.

The sufferer is, of course, unable to lessen the distance between his retina and his lens *(moving the magnifying-glass nearer to the paper) ;* he is also unable to flatten (weaken) his lens sufficiently *(employing a weaker magnifying-glass in the place of the one used).*

He is therefore reduced to the only other means of meeting the difficulty—he brings the object which he wishes to see, nearer to his eye *(moving the candle nearer to the glass).*

The surgeon who treats a case of myopia, however, adopts the plan of *employing a weaker glass.* He cannot actually lessen the strength of the crystalline lens, but he can readily neutralize a portion of its magnifying power, and this amounts to the same thing.

To attain this end he places in front of the eye a glass lens of the opposite kind—a lens which is thinner at its centre than at its margin, and which is

commonly called a concave, or diminishing, glass. This kind of lens, instead of collecting together (converging) all the rays of light which pass through it into a cone or pencil, possesses the property of rendering them divergent.

If, therefore, the rays of light which enter a short-sighted eye be made to first pass through a concave glass of exactly the right strength, they will strike the crystalline lens at precisely the correct angles, and will consequently be accurately focussed on the retina (Fig. 18).

The strength of the lens required to bring about the necessary elongation of the focus, naturally varies in proportion to the extent of the short-sightedness present.

Again, there is the case of an eye which is of the opposite form to the one just described; that is, rather flattened from before backwards—like an orange.

Then the converse effect takes place, and the rays of light strike the retina *before* they have come to a focus (Fig. 19).

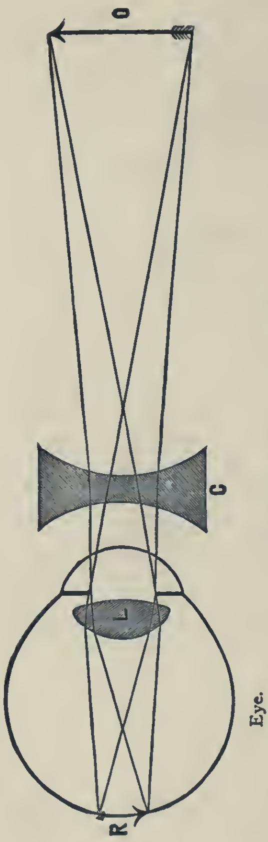



Fig. 18.—Myopia Corrected.

The Concave Lens, C, placed in front of the Eye causes the rays of light coming from the object, O, to diverge before passing through the Crystalline Lens, L, so that they are not brought to a focus until they reach the retina, R, where a clear image is produced.

N.B.—It is easy to prove that the magnifying effects of an ordinary convex lens (magnifying-glass) are diminished by allowing the rays to also pass through a glass of the opposite kind (concave lens). If the concave and convex glasses be of *equal* strength, they exactly neutralize each other. It is merely necessary to superimpose one glass on the other to see this at a glance.

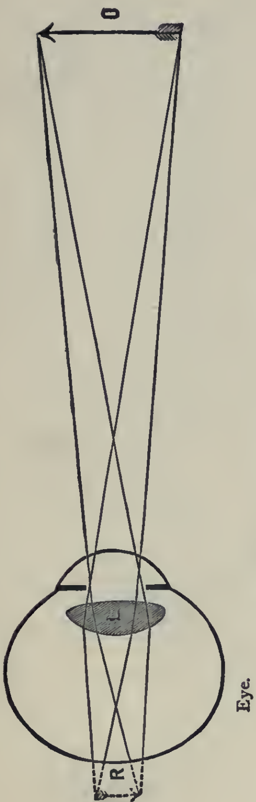



FIG 19.—HYPERMETROPIA ILLUSTRATED.

Eyeball too short (shallow) from before backward, therefore the rays of light strike the retina before they have come to a focus. Consequently the image is indistinct (Compare with Presbyopia Fig. 20).

The individual who possesses such an eye is said to be hypermetropic, or over long-sighted. He is generally able to see *distant* objects fairly clearly,

but has to strain to see near ones—in fact he may fail to read ordinary print unless the book be held at arm's length. As age advances, every eye becomes gradually more and more long-sighted. This occurs by reason of a change—a flattening—which invariably takes place, not so much of the eyeball itself as of the crystalline lens. The globe does perhaps alter a little, but the greatest flattening, by far, is in the lens.

This, of course, means that the lens becomes a weaker magnifier—and therefore rays of light passing through it do not converge so soon to a focus (Fig. 20).

The result is that much the same effect is produced, when looking at near objects, as in hypermetropia. The rays strike the retina before they have become focussed. This condition of flattening is known as presbyopia, and may be observed in most persons over forty years of age who attempt to read without glasses. These persons generally hold the print further off than when they were a few years younger.

It is found that this change in the form of the lens (causing presbyopia, or *old* sight) commences about the age of forty years. This is not per-

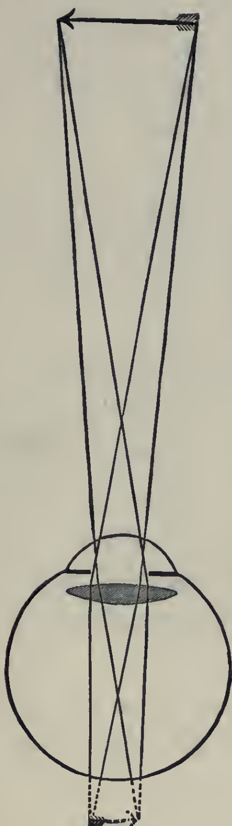


FIG 20.—PRESBYOPIA ILLUSTRATED.

The Crystalline Lens has become flattened (too weak) consequently the rays of light strike the retina before they have come to a focus. (Compare with Hypermetropia, Fig. 19).

ceptible from any outward appearance of the eye, but *gradually* makes itself felt.

At the age of forty the individual who has heretofore enjoyed excellent vision, for both near and distant objects, begins to find out that his sight for near ones is not quite so good as it was.

He may experience some trifling difficulty, and be conscious of a strain, in reading small print; and his eyes may even ache if the reading be sustained for any length of time.

Some while may yet elapse before he becomes convinced that this is so, but before very long he will feel no doubt on the subject.

Very short-sighted people never become over long-sighted—even in advanced age. The flattening process occurs; but this flattening is only sufficient to counteract a certain portion of the previous short-sight.

In hypermetropic persons, on the other hand, the *old* sight is added to the pre-existing *long* sight when the flattening commences.

The defective vision resulting from hypermetropia and presbyopia may be as easily corrected as in the case of myopia. The conditions are (practically) merely reversed.

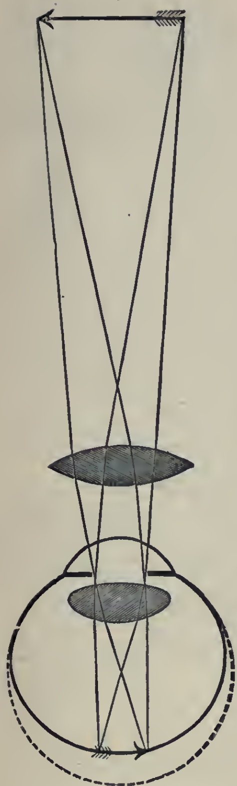


FIG. 21.—HYPERMETROPIA CORRECTED.

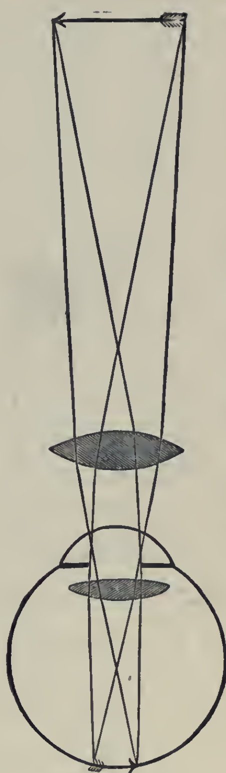


FIG. 22.—PRESBYOPIA CORRECTED.

Instead of a diminishing glass to lengthen out the pencils of light before they focus, a magnifying-glass, to shorten them, is required in front of the eye (Figs. 21 and 22).

When presbyopia has manifested itself in an individual hitherto free from defects of vision, the rate of progress in the flattening of the lens is curiously regular. So much so, that, knowing the age of the person, the right glass can be determined.

Short sight, long sight, and old sight having been described, we must now speak of another variety of defective vision. This is called astigmatism and is also due to a peculiarity of form.

We have seen that in myopia the eyeball is too deep (and the lens, therefore, too strong for it).

In hypermetropia the eyeball is too shallow.

In presbyopia the lens is too weak (flat).

But in all these cases the shape of the eyeball, whether too shallow or too deep, is *even* and symmetrical; and the lens, whether too weak or too strong in proportion to its distance from the retina, is regular as regards its curvature, and errs only in point of power.

In astigmatism, however, there is something more. Imagine an eye with the cornea shaped more like the bowl of a teaspoon than a watch-glass; and a lens like an *oval* glass-bead or button. This will give an idea, though an exaggerated one, of an astigmatic eye.

But in reality a defect analogous to this does exist. The cornea and lens are still circular in outline, but they are more sharply curved in one direction than in the others. But we know that in magnifying-glasses, the sharper the curve of the lens, the greater is the magnifying power. Consequently an astigmatic crystalline lens magnifies more in one direction (the one with the sharpest curve) than in the others. The variation from the correct shape is so slight that it cannot be discerned, by merely looking at it. It can only be detected by appropriate tests. But nevertheless the optical result is seriously affected; and at best, only a *partially-focussed* image is received by the retina.

As a rough illustration of the optical effect produced by the transmission of rays through an unequally curved medium, take a plain glass tumbler, full of water, aud hold it between the eye and a page of printed matter. The letters will appear magnified *in one direction only*—that is, they will seem broader, but not higher (as the circular curve of the tumbler is not up and down, but horizontal).

An egg-shaped wine-glass (sometimes seen in a wine merchant's counting-house) filled with water,

represents even more perfectly than a tumbler the unequal kind of refraction produced in an astigmatic eye. This pattern of wine-glass is slightly curved, like a barrel, vertically, as well as being circular in the horizontal direction; consequently, letters will be magnified in *all* directions, but more in the horizontal than in the vertical, the curve being sharper that way.

A person who is astigmatic, though he may not be aware that his eyes are deformed, generally experiences very uncomfortable sensations, such as running together of the lines of print; watering of the eyes, the whites of which are apt to become bloodshot; frequent headaches; "swimming" of the eyes; giddiness, &c.

Some, if not all, of these symptoms usually present themselves in astigmatism, and are aggravated after reading or doing fine work.

It is evident, from the previous remarks, that if the curvature of the lens be not mathematically correct and true in every direction, even though the remainder of the eyeball be well-shaped, the image or picture thrown on the retina will be indistinct in parts corresponding to erring portions of the lens.

An astigmatic person is so much in the habit of

receiving imperfect images—for the defect exists from early youth when it exists at all—that, unless the deformity be very marked, he often hardly realizes that this is not as it should be.

He probably attributes the redness of the eye to cold; the headache to simple neuralgia; the giddiness and bad vision to biliousness; the running together of the lines of print, and the watering, to that universal scape-goat, "weak eyes!"

In a

There is no special meaning in the expression *weak eyes.* It means either everything or nothing, at pleasure.

# PART V.

## TESTING THE VISION.

advt

It is of the highest importance to everyone—most especially to him whose vocation in life demands a constant use of the eyes—to know the exact state of affairs with regard to his vision.

There is but one reasonable course to be followed, viz., to subject the eyes to tests which may be relied on.

If they stand these tests, it will be satisfactory to know that all is right.

If, on the other hand, the tests reveal that something is wrong, it will be wise and prudent to remedy the evil and thus save the sight from failing prematurely.

advt

Various derangements of the eye are often associated with an uncorrected error of refraction. Such troubles as ulceration of the cornea; squint;

frequent headache; watering; irritability of the conjunctiva; and a host of minor ills, commonly accompany defective sight.

The much graver disease known as glaucoma, which, if neglected, generally leads to total blindness, is extremely liable to be excited by the strain attendant on incorrect vision, should a predisposition happen to exist.

Glaucoma is apt at times to come on very insidiously; and it is in such cases that proper spectacles, by the use of which all straining of the eyes is avoided, prove invaluable.

A well-known authority on ophthalmic surgery expressed himself in these words: "The number of eyes that come under our notice, trembling on the verge of glaucoma, is very astonishing; and the proportion of these cases appears to be on the increase."

Many, no doubt, remain in this dangerous condition; but it is just the eyes, "trembling on the verge of glaucoma," that may be placed beyond reach of harm by prompt and judicious treatment.

Spectacles often form an important feature in deciding which way the balance will turn; but ready-made glasses, bought hap-hazard at a shop,

are frequently a source of danger, whilst those which are accurately adjusted by an ophthalmic surgeon, who has carefully computed the *amount* of error, afford both comfort and safety.

The few remaining pages will be devoted to showing how to detect and recognize all errors in vision caused by the deformities already described.

What, then, are the means at our command for ascertaining whether our eyes are correctly formed, or whether they are optically misshapen?

There are a variety of ways by which an ophthalmic surgeon may readily estimate the exact amount of Myopia, Hypermetropia, and Astigmatism. But the employment of most of these methods requires some technical knowledge of the use of optical instruments. Consequently a description of them would here be out of place.

Fortunately, there is a simple plan for detecting errors of refraction which is within the reach of all.

It consists in determining with what amount of precision and facility the eye can read printed type of a given size at a measured distance; and whether the eye can distinguish with perfect clearness each one of a number of straight black lines drawn in a great many different directions.

Obviously, only one eye is to be examined at a time, the other being closed with the finger, or kept covered up.

The printed types are in two series, one of large letters, the other of small ones.

The large letters (commonly called the "Distant Types") are placed at a distance of 6 yards from the person desiring to test his vision.

The small letters ("Near Types") are held in the hand just 15 inches from the face.

E T, the largest of the distant types (which will be found in a pocket at the end of this little book) are of such a size that a sound, well-formed eye could read them easily at any distance up to 36 yards, for here each letter would exactly subtend an angle of five minutes (*Vide* Figs. 12 and 13).

The smallest letters of the same series, NOTXUB, should, for the same reason, be easily distinguished at 6 yards. It is therefore evident that a person with good sight, standing 6 yards from the distant types, would be able to read the whole set.

If, then, it be found that a difficulty is experienced in distinguishing any—even the smallest—of the letters of the distant types, it may be safely inferred that the sight is defective.

Very short-sighted persons cannot read even the large E T, and over long-sighted individuals may find the same difficulty, though probably to a less extent.

By attending carefully to the following instructions, a good idea of the condition of the sight of each eye may be obtained; and a correct conclusion may be drawn as to the necessity, or otherwise, of consulting an ophthalmic surgeon on the subject of spectacles.

It cannot be too firmly impressed on the reader that in order to obtain any information about the sight, it is *imperative* that only one eye be tested at a time, the other being kept closed or covered.

In every case the eye under examination is to be subjected to *all* the tests consecutively before the other eye is opened or uncovered. The second eye is then to be examined in the same way, the result for each eye being noted separately.

# TEST I.

## Distant Types.

### For the Detection of Myopia and Hypermetropia.

(*a*). Stand 6 yards from the distant types, which must be hung against the wall in a good light.

(*b*). Keeping one eye closed, and beginning at E T, read *aloud* all the letters which you can *clearly* distinguish.

(*c*). If you are able to read every letter of the distant types, pass on to Test II.

(*d*). If you fail to make out some of the letters, an error in vision exists in the eye you are testing, and spectacles are required. Note the smallest letters which you *are* able to read, for comparison with vision in the other eye. Pass on to Test II.

N.B.—If a *weak* convex (magnifying) lens placed in front of the eye, improve, or at any rate do not impair, vision, you are most probably hypermetropic, and should wear appropriate glasses *constantly*, to save your sight and prevent injury. But if a *weak* concave (diminishing) lens enables you to see better, you are most probably Myopic, and certainly require glasses for seeing distant objects—perhaps even for reading.

## TEST II.

### Fan.

#### For the Detection of Astigmatism.

(*a*). Stand 6 yards from the diagram of lines (one eye being closed or covered, as before). If you can see *none* of the lines, advance very gradually towards the diagram until you can see it, then stop.

(*b*). Look very carefully at the lines, and notice whether any of them appear blacker and more distinct than the others.

(*c*). If they all seem equally black and distinct, pass on to Test III.

(*a*). If some lines are more vividly black than the others, or if some of them are rather hazy, the eye under examination is Astigmatic, and a *specially* adjusted pair of spectacles is absolutely necessary.

# TEST III.

## NEAR TYPES.

### FOR THE DETECTION OF PRESBYOPIA.

(*a*). Hold the paragraphs of small print exactly 15 inches from the face, and stand in such a position as to get the best possible light on the page.

(*b*). If you can read the finest print quite easily, and without effort, with each eye, at the distance of 15 inches, there cannot be much (if any) optical error, provided the eyes have stood TESTS I. and II.

(*c*). If you find a difficulty in reading the smallest print, pass on to a paragraph which you can read easily at 15 inches—and notice whether you can read the same paragraph as comfortably when you move the page rather further from your face.

N.B.—If the difficulty encountered in reading the smallest print be due to Presbyopia, the larger paragraphs will probably be better seen at from 20 to 25 inches. But if, on the contrary, the print is seen better at 15 inches than at any greater distance, the impediment to reading the smallest type may lie in some other cause than Presbyopia.* It will be remembered that Presbyopia begins to be manifested about the age of 40; and most persons require glasses when 45 years old.

* *Vide* REMARKS which follow "Near Types."

## *NEAR TYPES.*

### *Type No. I. Brilliant.*

The period during which seeds retain their vitality is very variable. Melon-seeds have been known to vegetate after forty years. Seeds capable of germinating have been stated to have been found in a Roman tomb, fifteen or sixteen centuries old, (*M. C. Cooke.*)

### *Type No. II. Pearl.*

The common way in which we reason, is to expect that things will happen as they have happened before in like circumstances. Seeing a bright flash of lightning, I expect thunder to follow, because it has followed bright flashes of lightning in previous cases. (*Prof. Jevons.*)

### *Type No. IV. Minion.*

The eruption of Roseola is preceded for a day or two by slight febrile disturbance, which subsides as the rash becomes developed, and there is commonly some dryness and redness of the fauces. (*Balmanno Squire.*)

### *Type No. VI.—Bourgeois.*

Squint or Strabismus exists if the visual axes are not both directed to the same object. A squint may be the result either of overaction or of weakness or paralysis of a muscle: the internal rectus by excessive contraction often causes convergent squint; most other forms, as well as some convergent cases, result from actual defect of nervous or muscular power. (*Edward Nettleship.*)

### *Type No. VIII.—Small Pica.*

It would appear then to be a just conclusion from these data, that infectiveness is no longer to be considered as a mark of specificity, but that it is a property resident in every inflammation and every fever, even in those arising from the commonest, and most unspecific, causes. (*W. J. Collins.*)

*Type No. X—Pica.*

Reptilia furnish the most numerous and important examples of venomous animals, and these are limited almost entirely to the order Ophidia or snakes. (*Sir Joseph Fayrer*).

*Type No. XII.—Great Primer.*

Many of the patterns of Molar teeth in Rodents are very beautiful, their form being mostly maintained by various dispositions of dentine and enamel. (*F. H. Balkwill.*)

# REMARKS.

When hypermetropia exists in small or only moderate degrees, the Test I. may fail to detect it (especially in a young person) as distant objects are often seen pretty well in these cases. But it will be found that in even small degrees of hypermetropia a very weak magnifying-glass in front of the eye will not be an impediment to vision—which it certainly would be if the sight were perfect.

The rule in choosing glasses for the correction of hypermetropia, is therefore to adopt the *strongest* ones through which the smallest row of letters in the "Distant Types" can be clearly seen.

In myopia, on the contrary, it is only safe to wear the *weakest* concave lens through which the smallest "Distant Types" can be read; and even this lens would most probably be too strong for near work, such as reading, writing, sewing, &c.

The "Near Types" alone afford no information

respecting the choice of spectacles, except in cases of purely old sight (presbyopia).

These remarks are made, not with the view of tempting the reader to purchase glasses of his own selection, but rather to point out the necessity for seeking proper assistance (for fear of making a wrong choice) should the TESTS reveal defective vision.

It has been assumed, so far, that putting aside such impediments as atmospheric effects, &c., there is no barrier to clear vision beyond a possible optical error; whereas it is not infrequently found that a scar (nebula) resulting from an ulcer of the cornea, or may be a commencing cataract, is the real obstacle.

In cases of this sort spectacles alone would probably not much improve the vision.

Before dismissing the subject of vision-testing, reference must be made to *colour-blindness*.

This curious lack of appreciation—or, perhaps, more strictly speaking, of differentiation, is more common than may be supposed.

Without going at all into the theory of colour, it will be sufficient to say that when colour-blindness exists it is usually *partial*, and not *complete*.

It generally makes itself apparent by an inability to distinguish various shades of one given colour from corresponding shades of some other colour,

all colours besides these being seen properly. But in *total* colour-blindnes no difference is noticed between *any* colours, *light* and *shade* only being recognized.

In the commoner variety it may be easy to distinguish between browns and blues, but perhaps impossible to see any difference between greens and reds.

The ordinary test consists in mingling together a great number of skeins of Berlin wool, representing many shades of different colours, and endeavouring to pick out *all* the shades of *one* colour. If colour-blindness be present, mistakes are likely to be made between dark greens and intense reds or browns; or between pale greens and pinks or buffs—these being the colours most frequently confused, though they are by no means the only ones.

It is evident that if colour-blindness were overlooked in railway-guards, engine-drivers, signalmen, pointsmen, sailors, and others, the most serious accidents might reasonably be expected to occur. Indeed many disasters of this kind have been traced to this unfortunate defect.

# CONCLUSION.

In taking his leave of the Reader, the author is constrained to say a few words respecting the contents of this little work. He is conscious that the picture he has drawn is faint and incomplete. Full justice to a description of the human eye would involve a treatise greatly exceeding the proportions of this little volume.

For this reason no allusion has been made—even in the most elementary manner—to many important points, such as binocular vision, stereoscopic effects, estimation of bulk and form, perspective, retension of impressions on the retina, complementary colours, &c., &c.,—as well as the more minute and strictly accurate anatomical and physiological features of the various structures which together compose the optical machinery we call the eye.

On all these points the author feels that much remains to be told.

He is inclined to believe, however, that these omissions are a fault on the right side; and at some future time he may be tempted to complete the story here begun.

# APPENDIX.

## RULES RELATING TO VISION

OF CANDIDATES FOR ADMISSION

TO THE

VARIOUS DEPARTMENTS

OF THE

## INDIAN GOVERNMENT SERVICE, THE BRITISH ARMY, AND ROYAL NAVY.

I am indebted to Surgeon-General Sir Joseph Fayrer for the information contained in the following pages.

The regulations in force respecting vision of candidates for Commissions in the Army and Navy are to be found in Surgeon-General Sir T. Longmore's Manual. But those relating to candidates for admission to the various branches of the Indian Government Service have been compiled by Sir Joseph Fayrer, after consultation with Mr. Macnamara, Mr. Couper, and Brigade-Surgeon H. Cayley.

I cannot too strongly urge on intending candidates for the Public Service the advisability of submitting their eyes to the practical Tests described in the preceding part of this work, so that they may form some opinion of their fitness to stand this portion, at any rate, of the Physical Examination.

A. ST. CLAIR BUXTON.

18, Orchard Street,
Portman Square, W.

---

The tests to which candidates are subjected are virtually identical with those given in Part V. of "Vision and Vision-Testing;" and it may be taken

for granted that a candidate whose eyes stand each one of those tests perfectly will not be rejected.

If, however, there should be the least hesitation on the part of the candidate, the examining surgeon will proceed to a further and more precise optical investigation, and should any error of refraction be detected, the exact nature and *amount* of that error will be carefully computed.

A certain latitude in the acuteness and range of vision is allowed in most branches of the Public Service, but the amount is clearly laid down, and must not be exceeded.

The terms Myopia, Hypermetropia, and Astigmatism are explained in Part IV. of "Vision and Vision-Testing," page 43.

---

# INDIAN GOVERNMENT SERVICE.

## CIVIL SERVICE.

*(Covenanted and Uncovenanted.)*

A candidate may be admitted into the Civil

Service even though an error of vision exist in both eyes provided :

(1).—That no disease be detected in the interior of the eye.

(2).—That spectacles enable the candidate to read the smallest row of letters of the Distant Types at the full distance (6 yards) with at least one eye; and the last row but one with the other eye.

(3).—That the error in neither eye exceed that which can be completely neutralized by a lens having a focal length of 16 inches (2·5D) or by a weaker lens.

(4).—That if the defect of vision should arise from a *nebula* (opacity)* of the cornea, the defective eye can read the last row but two of letters of the Distant Types at the full distance (6 yards), and that the other eye can read the last row perfectly. Spectacles to attain this result are allowed (up to the strength mentioned in clause 3).

* *Vide* page 69.

## PUBLIC WORKS, FOREST, SURVEY, TELEGRAPH, RAILWAY, FACTORIES, &c.

Candidates, the subjects of Myopia, are not disqualified if with lenses of 16 inches (2·5D) focal length, or weaker lenses, they are enabled to read, with at least one eye, the last row of letters of the Distant Types at the full distance (6 yards), and with the other eye the last row but one.

In such cases, however, there must be no active disorder within the eye.

The same rule applies in cases of Myopic Astigmatism, and the total strength of the lenses employed to correct the error must not exceed the standard above named.

Hypermetropia does not disqualify provided the vision can be brought up to the same degree of acuteness as in the case of Myopia with lenses of 10 inches (4D) focal length, or weaker lenses. In testing this defect, however, the eyes must be under the influence of atropine.

The same rule applies in cases of Hypermetropic Astigmatism, and the total strength of the lenses employed to correct the error must not exceed the standard above named.

Candidates whose vision is defective on account of a *nebula* (opacity) of the cornea, come under the rule concerning this obstacle found under the head of Civil Service.

---

## INDIAN MEDICAL SERVICE.

*(Covenanted and Uncovenanted.)*

Myopic candidates are not disqualified provided that with lenses of 8 inches (5·D) focal length, or with weaker lenses, they can read, with at least one eye, the last row of letters of the Distant Types at the full distance (6 yards), and the last row but two with the other eye. No active disorder must exist within the eye.

The above holds good in cases of Myopic Astigmatism.

Hypermetropia does not disqualify, provided that with lenses of 8 inches (5·D) focal length, or with weaker lenses, the candidate can read, with at least one eye, the last row of letters of the Distant Types at the full distance (6 yards), and the last row but two with the other eye. The eyes are to be tested under the influence of atropine.

The above holds good in cases of Hypermetropic Astigmatism.

Candidates whose vision is defective on account of a *nebula* (opacity) of the cornea, come under the rule concerning this obstacle found under the head of CIVIL SERVICE.

---

## PILOT SERVICE.

Absolutely perfect vision with each eye is a *sine quâ non.* No spectacles are allowed.

---

## MARINE SERVICE.

*(Including Engineers and Firemen.)*

A candidate is disqualified if he possess any error of refraction which is not completely corrected by lenses of 40 inches (1·D) focal length, or by weaker lenses.

N.B. – Candidates for the various departments of the Indian Government Service may also be disqualified by such obstacles as double-sight; squint; paralysis of external muscles of the eye; colour-blindness; pathological changes, or morbid condition of the eye, &c. For colour-blindness, see page 69.

To place an eye under the influence of atropine it is merely necessary to apply inside the lower lid one or two drops of the Pharmacopœia "Solution of Sulphate of Atropine." In about half-an-hour the pupil will become widely dilated, and the full effect of the drug will be produced.

It is right to warn the reader that the sight for near objects is rendered extremely dim by atropine, and that this dimness generally lasts for several days.

# MILITARY SERVICE OF GREAT BRITAIN.

In the examination of candidates for commissions, or of recruits for employment, in the British Army, the regulation Test Dots take the place of the Distant Types.

The following diagram is a fac-simile of the ordinary circular dots used :—

A certain number only of the dots are exposed to the man under examination. They are held at a stated distance from him (according to the arm of the service he seeks to enter), and he is required

to see the number, as well as the relative position, of the dots, with each eye separately. Each dot corresponds, at a distance of 10 feet, with a bull's-eye 3 feet in diameter at 600 yards. The answers must be given readily and without any hesitation.

Spectacles may be worn during this examination.

---

## ROYAL ARTILLERY AND ROYAL ENGINEERS.

Candidates are required to see a bull's-eye 2 feet square at a distance of 900 yards (with each eye). Special *square* test dots are employed during this examination.

An approximate idea of the test, however, can be obtained by attempting to read the *circular* test dots, shown in the diagram, at a distance of 22½ feet, with one eye at a time.

Ordinary concave and convex spectacles are allowed.

## CAVALRY AND INFANTRY OF THE LINE.

Candidates are required to see distinctly, and to be able to count, the circular test dots held at a distance of 10 feet, in a good light. Each eye is examined separately. Ordinary concave and convex spectacles are allowed. (For militia and departmental corps recruits, the dots are held only 5 feet off).

---

## MEDICAL STAFF.

A moderate degree of error of refraction is allowed, provided that, in the opinion of a Board of Medical Officers, the candidate's vision is sufficiently good to enable him to perform surgical operations without the aid of spectacles; and also provided that there is no organic disease of the eyes.

N.B.—"Although all candidates for commissions in the Army are allowed to use glasses when being tested as to the power of sight, the military authorities retain the power of deciding in every instance of Myopia or defective vision, according to its special characters, whether the candidate is to be declared visually fit or unfit for the military service."

# ROYAL NAVY.

It appears that there are no printed rules respecting Vision Testing for the Navy. Sir T. Longmore states that "Candidates for commissions in the Royal Navy are not considered eligible who are subjects of any degrees of Myopia or Hypermetropia."

They must therefore be able to read every line of the Distant Types at the full distance (6 yards) and also every paragraph of the Near Types—the eyes being under the influence of atropine for the Distant Types.

"Exceptions are, however, made in some special cases under particular circumstances, but the discretionary margin allowed is very limited."

The same rule applies to the Medical Service; and also to Engineer students, whence the Engineers of the Navy are derived; as well as to boys for the Navy, seamen, stokers, artificers, and marine recruits.

Colour-blindness disqualifies. *Vide* page 69.

No spectacles are allowed.

---

T. G. Burns & Co., Printers, 170a, Great Portland Street, W.

# OPTOMETERS, &c.

| | £ | s. | d. |
|---|---|---|---|
| Gowan and Brailey's Optometer, for the quick determination of refraction in the ordinary way and by Keratoscopy ... ... ... ... ... ... | 11 | 11 | 0 |
| Tweedy's Optometer, complete on stand ... ... ... | 1 | 5 | 0 |
| Couper's Optometer, with revolving disc, fitted with cylindrical lenses ... ... ... ... ... ... | 7 | 7 | 0 |
| Critchett's Chart for measuring the field of vision ... ... | 0 | 2 | 6 |
| Ditto do., mounted on linen ... ... ... ... ... | 0 | 7 | 6 |
| Purves' Meridian Delineator ... ... ... ... ... | 2 | 2 | 0 |
| Scheiner's Optometer ... ... ... ... ... ... | 0 | 5 | 0 |
| Stokes' Lens ... ... ... ... ... ... ... | 1 | 5 | 0 |
| Purves' Astigmatic Clock ... ... ... ... ... | 0 | 5 | 0 |
| Carter's Astigmatic Clock ... ... ... ... ... | 0 | 15 | 0 |
| Professor Holmgren's Worsteds ... ... ... ... | 0 | 5 | 0 |
| Jeafferson's Patent Colour Circle ... ... ... ... | 2 | 0 | 0 |
| Professor Snellen's coloured transparent Types (framed) with the requisite spectacles for detecting feigned blindness in either eye ... ... ... ... ... | 1 | 5 | 0 |
| Dr. Parent's Artificial Eye for demonstrating myopia, hypermetropia, astigmatism, &c., &c. ... ... ... | 4 | 4 | 0 |
| Professor Snellen's Phakometer, as modified by Professor McHardy ... ... ... ... ... ... | 5 | 10 | 0 |
| American Eye Shades ... ... ... ... ... ... | 0 | 0 | 9 |
| Test Type for distant vision mounted on framed board ... | 0 | 4 | 6 |
| Ditto do., two Test Types (one on each side of board) ... | 0 | 6 | 0 |
| Astigmatic Fan mounted on framed board ... ... ... | 0 | 3 | 6 |
| Pray's Astigmatic Letters do. ... .. ... | 0 | 4 | 0 |
| Astigmatic Clock do. ... ... ... | 0 | 12 | 0 |
| Transparent Types for use with mirror in any short consulting room ... ... ... ... ... ... | 0 | 10 | 6 |
| Frost's Artificial Eye (see Illustrated Pamphlet) ... ... | 2 | 5 | 0 |

## NEW SELF-REGISTERING PERIMETER.

Designed by Professor McHardy (*vide* "Ophthalmic Review," February and March, 1882.

Price £8 10s od. Complete in Case.

Geared for Automatic Registration on two scales, especially adapted for determination of the "Angle of Strabismus," the "Angle and the Field of Fixation."

Mr. Priestley Smith's PERIMETER.

Price £4 4s. od. *Charts 5s. per 100.*

# SPECTACLES.

NOTE.—*Cases are always charged additional.*

| | £ | s. | d. |
|---|---|---|---|
| Best quality hand-made Spectacles, accurately adjusted to the face, and fitted with spherical lenses ... ... | 0 | 8 | 6 |
| Second quality, do. do. ... ... ... ... ... | 0 | 6 | 6 |
| Machine made do. for Hospitals ... ... ... ... | 0 | 2 | 6 |

NOTE.—*These cannot be accurately adjusted to the face.*

| | £ | s. | d. |
|---|---|---|---|
| Best quality hand-made Spectacles, accurately adjusted to the face, and fitted with spherical lenses of 4 inches focus and less ... ... ... ... ... ... | 0 | 10 | 6 |
| Best qnality do. do., fitted with tinted lenses ... ... | 0 | 10 | 6 |
| Best quality do. do., fitted with tinted lenses of 4 inches focus and less ... ... ... ... ... ... | 0 | 13 | 6 |
| Best quality do. do., fitted with astigmatic or prismatic lenses ... ... ... ... .. ... ... | 0 | 15 | 0 |
| Best quality do. do., either surface having a focus of 4 inches or less ... ... ... ... ... ... | 0 | 18 | 6 |
| Second quality do. do., fitted with astigmatic or prismatic lenses ... ... ... ... ... ... ... | 0 | 12 | 6 |
| Second quality do. do., fitted with astigmatic lenses, either surface having a focus of 4 inches or less ... ... | 0 | 15 | 0 |
| Best quality do. do., fitted with astigmatic or prismatic lenses of any tint ... ... ... ... ... | 0 | 18 | 6 |
| Best quality cup shape Eye Preservers, any tint ... ... | 0 | 8 | 6 |
| Second quality do. do. do. ... ... ... ... ... | 0 | 6 | 6 |
| Best quality do. do. do., fitted with any sight and any tint | 0 | 15 | 0 |
| Best quality do. do. do., with wire gauze sides, fitted with lenses of any tint ... ... ... ... ... | 0 | 16 | 0 |
| Best quality do. do. do., with any sight and any tint ... | 1 | 2 | 6 |
| Best quality Goggles with wire gauze cups, and fitted with plane lenses of any tint ... ... ... ... | 1 | 16 | 0 |
| Best quality do. do., fitted with lenses of any tint, either spherical, astigmatic, or prismatic ... ... ... | 1 | 2 | 6 |
| Horseshoe Eye Preservers, fitted with plane lenses of any tint ... ... ... ... ... ... ... | 0 | 10 | 6 |
| Spectacle Cases (frogmouth or tuck) ... ... ... | 0 | 1 | 0 |
| Velvet and silk-lined Box Case with snap ... ... ... | 0 | 2 | 6 |
| Best quality gold hand-made Spectacles, fitted with lenses from | 1 | 15 | 0 |
| Turnpin sides to Spectacles ... ... ... ... extra | 0 | 2 | 0 |
| Grooved lenses to Spectacles ... ... ... ... extra | 0 | 2 | 0 |

*N.B.—Spectacles are supplied to Surgeon's prescriptions only.*

# OPHTHALMOSCOPES.

| | £ | s. | d. |
|---|---|---|---|
| Couper's New Magazine Refraction Ophthalmoscope, with 72 lenses and swinging mirror ... ... ... | 5 | 5 | 0 |
| Do. do. with automatic shutter to Index wheel, or Johnson's mirror arrangement ... ... | 6 | 6 | 0 |
| Couper's Student's Magazine Ophthalmoscope, with automatic shutter (36 lenses) ... ... ... ... | 3 | 3 | 0 |
| Or with Johnson's double mirror arrangement ... | 3 | 3 | 0 |
| Morton's Ophthalmoscope (as described in pamphlet) ... | 3 | 3 | 0 |
| Johnson's Ophthalmoscope (see Pamphlet, post free on application ... ... ... ... .. ... | 3 | 10 | 0 |
| Couper's Refraction Ophthalmoscope with swinging mirror, fitted with 12 concave and 12 convex lenses in a Rekoss disc ... ... ... ... ... | 2 | 2 | 0 |
| Couper's do. do. Twin Ophthalmoscopes, fitted with 24 concave and 24 convex lenses... ... The pair | 4 | 4 | 0 |
| Brailey's Ophthalmoscope, with 18 lenses ... ... ... | 1 | 5 | 0 |
| Paxton's Ophthalmoscope, with 18 lenses, and Johnson's double mirror arrangement ... ... ... ... | 1 | 15 | 0 |
| Cross Opthalmoscope, with 15 lenses, and mirrors of 3″ and 10″ focus respectively, packed in exceedingly small purse cases ... ... ... ... ... | 1 | 15 | 0 |
| Parent's Ophthalmoscope ... ... ... ... ... | 1 | 15 | 0 |
| Juler's Ophthalmoscope, including the Revolving Mirror, a Convex Lens, and a Case ... ... ... ... | 2 | 0 | 0 |
| Electric Lamp and its Fittings ... ... ... ... | 0 | 17 | 0 |
| Battery, including a Resistance Coil ... ... ... | 2 | 2 | 0 |
| Purves' Refraction Ophthalmoscope ... ... ... ... | 4 | 0 | 0 |
| Oldham's Ophthalmoscope for general practitioners... from | 0 | 15 | 0 |
| Loring's Ophthalmoscope ... ... ... ... ... | 3 | 0 | 0 |
| Westminster Ophthalmoscope ... ... ... ... | 2 | 10 | 0 |
| Gower's Ophthalmoscope ... ... ... ... ... | 1 | 15 | 0 |
| Do. do. (Mr. Nettleship's modification) ... ... | 2 | 2 | 0 |
| Adams' Forehead (artist's) Ophthalmoscope with double discs ... ... ... ... ... ... ... | 3 | 10 | 0 |
| Adams' Single do. do. ... ... ... ... ... | 2 | 10 | 0 |
| Adams' Cornea Illuminator ... ... ... ... ... | 1 | 15 | 0 |
| De Wecker's Refraction Ophthalmoscope ... ... ... | 1 | 10 | 0 |
| De Wecker's Metrical Ophthalmoscope ... ... ... | 1 | 15 | 0 |
| Landholt's Ophthalmoscope ... ... ... ... ... | 1 | 18 | 0 |
| Mirror for Keratoscopy or Retinoscopy ... ... ... | 0 | 7 | 6 |
| Do. do. Dr. Brailey's form ... ... ... | 0 | 10 | 0 |
| Condensing lens 2 inches diameter, 3 inches focus ... ... | 0 | 2 | 6 |

# BINOCULAR
# FIELD AND OPERA GLASSES.

| | Field £ s. d. | Opera £ s. d. |
|---|---|---|
| No. 1. Binocular Glass $1\frac{3}{10}$ inch diameter, | 2 0 0 | 1 10 0 |
| No. 2. do. do. $1\frac{4}{10}$ inch do. | 2 10 0 | 2 0 0 |
| No. 3. do. do. $1\frac{7}{10}$ inch do. | 2 15 0 | 2 5 0 |
| No. 4. do. do. $1\frac{9}{10}$ inch do. | 3 0 0 | 2 10 0 |
| No. 5. do. do. $2\frac{1}{10}$ inch do. | 3 10 0 | 3 0 0 |
| No. 1. Alumn. Binclr. Glass $1\frac{3}{10}$ in. diam., | 5 10 0 | 3 10 0 |
| No. 2. do. do. $1\frac{4}{10}$ in. do. | 6 0 0 | 4 0 0 |
| No. 3. do. do. $1\frac{7}{10}$ in. do. | 6 6 0 | 4 15 0 |
| No. 4. do. do. $1\frac{9}{10}$ in. do. | 6 16 6 | 5 10 0 |
| No. 5. do. do. $2\frac{1}{10}$ in. do. | 7 7 0 | 6 10 0 |

*For particulars and prices of*

PICKARD & CURRY'S TELESCOPES.
PICKARD & CURRY'S THERMOMETERS.
PICKARD & CURRY'S BAROMETERS
PICKARD & CURRY'S ANEROIDS.
PICKARD & CURRY'S PEDOMETERS.
PICKARD & CURRY'S CHARM COMPASSES.
PICKARD & CURRY'S READERS.
PICKARD & CURRY'S CHATELAINE CASES.

Apply to PICKARD & CURRY, Ophthalmic Opticians, 195, Gt. Portland St., London, W.

(*Branch*—8, HARDMAN STREET, LIVERPOOL).

T. G. Burns & Co., Printers, 170a, Great Portland Street, W.

# Restricted Book

The borrowing of this book is subject to the restriction as checked below.

1. May be used only in the library–not to be withdrawn at any time.
2. May only be withdrawn from 4 P.M. until 9 A.M. of the following day.
3. May be borrowed for a period of 24 hours.
4. May be borrowed for a period of 7 days.

---